

spondent "A. B." draws attention, there can be no doubt, so far as it is regarded as a storehouse of information; but whether the system of classification proposed therein will not tend to retard rather than to further progress is a question on which I am at present more than doubtful. The two points to which Dr. Hatch and your correspondent draw attention as inherent weaknesses—viz. the "dyke rocks," and the subdivision of the "effusive rocks" into palæo-volcanic and neo-volcanic—appear to me such serious defects, that to praise a system which largely rests on them is like complimenting a viaduct by saying that it is an excellent viaduct but two of its piers unfortunately have a bad foundation.

But dismissing this as a question too large for discussion in your columns, I will confine my remarks to some defects in detail, rather serious as they appear to me, which are exhibited by the classification as tabulated by your correspondent.

(1) A mere "linear" classification fails, I believe, to represent satisfactorily the relation of the igneous rocks, because it separates too widely rocks very closely related—such, for instance, as the Dacites and Rhyolites (Liparites), and their corresponding holocrystalline representatives. Hence I believe that the branching system such as I indicated in my Presidential Address to the Geological Society in 1885 is more logical and more in accordance with the facts of Nature.

(2) In regard to the above example, I fail to understand why Dacites should be included with Andesites and Liparites separated from Trachytes, or, if we speak of their holocrystalline representatives, why we should separate Granite from Syenite, while we include Tonalite with Diorite. It is true that Granites are common and Tonalites are rare, and possibly the latter always contain some hornblende; but until it is shown that a quartz-plagioclase-biotite rock does not exist, or that the substitution of hornblende for biotite is of primary importance, there does not seem any valid reason for suppressing the group.

(3) As the term Diabase has long had a recognized meaning, I fail to see any good reason for substituting it for Dolerite, to which, as generally understood, it stands in much the same relation as do many Serpentine to Peridotites. Neither can I admit the propriety of separating Gabbro from it.

(4) The wide separation of the Leucite and Nepheline rocks from the Basalts seems also to me to be of doubtful advantage.

(5) If the term Peridotite be used in the sense in which it has generally been employed (e.g. by Dr. Wadsworth in his excellent "Lithological Studies")—namely, to denote a rock in which silicates of magnesia and iron abound, with some also containing lime but with little alumina—it is surely not possible to regard Limburgite as its "effusive" equivalent. That rock seems to me to be more properly associated with the Picrites, not as defined by Dr. Wadsworth (i.e. olivine-augite rocks), but as equivalent to the Palæopicrites of some authors—viz. pyroxenic rocks, containing a fair amount of olivine, and some feldspar, which last, however, has a very variable proportion. The true position of these rocks appears to me to be as a connecting-link between the Peridotites and the Dolerites.

There are other points in the work to which I should like to call attention, but I am writing away from books, and should have refrained for a season had not "A. B.'s" letter seemed to me to call for a word of friendly protest. No one can be more deeply sensible than I am of the value in many respects of Prof. Rosenbusch's work, but until his classification rests on a firmer foundation it will not, I fear, be really helpful to students in leading them to clearer ideas on a complicated and difficult subject.

T. G. BONNEY.

The Delicacy of the Sense of Taste.

AT the Philadelphia meeting of the American Association, in 1884, we presented a paper upon the general subject of the "Sensitiveness of the Special Senses." We have since continued our investigations,¹ and have the honour to present at this time the results of some experiments upon the sense of taste.

The object of the experiments herein described was to find out what substances, or classes of substances, are most readily detected by the sense of taste, and the relative delicacy of this

sense towards these substances. For the production of familiar typical effects upon the organs of sense the following substances were selected:—

I. (bitter)	.	.	.	Quinine.
II. (sweet)	.	.	.	Cane sugar.
III. (acid)	.	.	.	Sulphuric acid.
IV. (alkaline)	.	.	.	Sodium bicarbonate.
V. (saline)	.	.	.	Common salt.

The attempt was made to include other substances in this list, but it was difficult to find any, not embraced in the five classes above mentioned, which would not betray their presence either by colour or odour. Indeed it is surprising, to one who has not given the subject attention, to what an extent we are accustomed to depend upon the aid of the sense of smell in the classification of tastes. The fact has been noticed by several authors that, if the nostrils are closed, the range of our taste becomes very much limited.

Our method of testing the delicacy of the sense of taste was to make solutions, of known strength, of the different substances; then, by successive dilutions, to make from these several series of weaker solutions; each one being of one-half the strength of that preceding it. All the bottles containing these substances, and several bottles of water, being placed side by side without regard to order, the person to be tested was requested to taste of each solution and place it in its proper class. In each series the lowest solution was so very dilute that it was deemed impossible to distinguish it from water. Unknown solutions were to be classed with water. As the tasters were found to be liable to mistake occasionally even the stronger solutions, an opportunity was given, at the close of the test, to correct such accidental errors. In carrying out these tests we found that the most trustworthy results were to be obtained by instructing each operator to pick out the stronger solutions, temporarily classifying with water all which were not immediately recognized; and then to go over the latter solutions a second time, properly classifying such as could further be detected.

These tests were made by 128 persons, between the ages of twelve and fifty—eighty-two men and forty-six women. The average results are given in the following table:—

Table of Averages.

I. Quinine.				
Male observers detected 1 part in	390,000	parts of water.		
Female " " 1 " "	456,000	" "		
II. Cane sugar.				
Male observers detected 1 part in	199	parts of water.		
Female " " 1 " "	204	" "		
III. Sulphuric acid.				
Male observers detected 1 part in	2080	parts of water.		
Female " " 1 " "	3280	" "		
IV. Bicarbonate of soda.				
Male observers detected 1 part in	98	parts of water.		
Female " " 1 " "	126	" "		
V. Common salt.				
Male observers detected 1 part in	2240	parts of water.		
Female " " 1 " "	1980	" "		

This table indicates only the average delicacy of taste for each substance included in our experiments. The tests brought to light many astonishing individual peculiarities. For instance, there were persons who could detect with certainty 1 part of quinine in 5,120,000, while others failed to notice 1 part in 160,000. How far this difference is due to education it is not possible to say. Among the tasters were quite a large number who had been accustomed for several years to the handling and recognition of drugs and chemicals. Their record was considerably above the general average, but they were, on the other hand, surpassed by a few individuals who had had no previous training.

The results of our experiments may be briefly summed up as follows:—

1. The sense of taste is much more delicate for bitter substances than for the others included in our list. (The relative delicacy for quinine and sugar is very nearly 2000:1.)

2. Taken in the order of their effect upon the organs of taste,

¹ See the following papers:—"On the Relative Bitterness of different Bitter Substances" (Proceedings of the Kansas Academy of Sciences, 1885); "On the Relative Sweetness of different Sugars" (Reports of the Kansas Board of Agriculture, 1885); "On the Sensitiveness of the Eye for Colours of a Low Degree of Saturation" (*American Journal of Science*, III. vol. xxx. p. 27); "The Sense of Smell" (*NATURE*, vol. xxxv. p. 74).

the classes of substances used stand as follows: (1) bitters; (2) acids; (3) saline substances; (4) sweets; (5) alkalies.

3. The sense of taste is as a rule more delicate in women than in men (in the case of all substances tried excepting salt). The number of persons experimented upon was hardly sufficient, considering the very striking individual peculiarities met with in the course of our investigation, to permit us to lay great stress upon the relative averages obtained for the two sexes. We are not inclined, however, to regard the higher degree of sensitiveness shown in the averages for female observers as accidental, and our confidence in the approximate value of the results is strengthened by the fact that in the two portions into which our data naturally divided themselves, about half the tests having been made at a different time and under different circumstances from the remainder, the averages for each set agreed very well, not only as to the relative sensitiveness to the various substances employed, but also to the relatively higher degree of delicacy exhibited by women.

4. The ability to detect a dilute bitter is very generally accompanied by inability to detect a dilute sweet, and *vice versa*.

5. The long-continued habitual use of a substance does not seem to influence in any marked way the delicacy of the sense of taste for that substance. Our tests with quinine afforded an excellent opportunity for the investigation of this point, as some of the persons experimented upon had made long continued use of that drug as a medicine. The results obtained were entirely of a negative character. We could discover neither increase nor decrease in the ability to taste the drug on the part of those habituated to its use.

Several other questions have been raised but not answered by our experiments. How many, for instance, of these substances, each being diluted in proportion to its effect upon the organs of taste, can be detected if mixed together? If so mixed, in what order will they be recognized, and will it always be in the same order by different persons? Again, what is the influence of the temperature of the solution upon our ability to taste its ingredients?

We deplore the fact that the above tests have not been extended to a much larger number of persons, but a careful study of the results of the limited number of experiments made leads us to believe that they do not differ widely from the probable averages of a much more extended series.

University of Kansas, July 1887.

E. H. S. BAILEY.
E. L. NICHOLS.

The Salt Industry in the United States.

HAVING occasion not long since to look up the statistics of the salt industry, I naturally turned to the latest edition of the "Encyclopædia Britannica" (vol. xxi.), where the following statement met my eye:—"The deposits of salt in the United States are unimportant. The country possesses no really considerable salt industry, but is supplied so far as interior consumption is concerned to a small extent by brine springs."

As this did not at all correspond with the knowledge I had gained by a somewhat casual glance over the field, I took pains to look up the subject more thoroughly, and find the above statement so radically wrong that I venture to call your attention to it; though this I should scarcely have troubled myself to do had it appeared in any publication of less acknowledged authority. To be sure, we have no means of knowing just how great an industry must be to be classed as "really considerable," but by comparing the annual product of the United States with that of other countries we may claim, at least, an attempt at an approximation.

But first as to the character of the beds in the United States. It is true there are as yet known no beds comparable in depth and extent with those of Barcelona or Galicia, but nevertheless they are amply sufficient to supply all demands for ages. As long ago as 1869, Dr. Sterry Hunt published, in the Reports of the Geological Survey of Canada, results of borings at Goderich, Canada, in which, in a total depth of 1382 feet, six successive beds of salt were passed through, varying in thickness from 6 to 34 feet, and aggregating a total thickness of 126 feet. What area is covered by these deposits is yet to be ascertained; but they are known to extend over Central and Western New York, Northern Pennsylvania, North-Western Ohio, and Southern Ontario. At Warsaw, in New York State, one of the beds has a thickness of 80 feet. The extent of the deposit at Petite Aïnse, Louisiana, has also yet to be determined, but a vertical shaft 165 feet in depth lies all the way in solid salt, and does not

penetrate it. The above, although but two out of many, I mention since they have been known for years, and it would seem Mr. Lyte could have informed himself regarding them had he so attempted. Concerning the many extensive beds in the region of the Great Basin, ignorance is more excusable. Statistics showing the annual output of both rock and sea salt will best show the extent of the industry. I give below statistics for 1883, 1884, and 1885, taken from "Mineral Resources of the United States," p. 474. One barrel equals 280 lbs.

	1883. Barrels.	1884. Barrels.	1885. Barrels.
Michigan	2,894,672	3,161,806	3,297,403
New York	1,619,486	1,788,434	3,304,787
Ohio	350,000	320,000	306,847
West Virginia ...	320,000	310,000	223,184
Louisiana	265,215	223,964	229,271
California	214,286	178,571	221,428
Utah	107,143	114,285	107,140
Nevada	21,429	17,857	28,593
All other States and Territories ...	400,000	400,000	250,000
Totals	6,192,231	6,514,937	7,038,653

Complete statistics for all countries are not available, and I have to rely to a considerable extent on Encyclopædias, whose accuracy I now have reason to question. They are as follow:—

England (1881) ...	1,854,000 tons.
France	300,000 "
Spain	300,000 "
Portugal	250,000 "
Italy	165,000 "
Austria	400,000 "

	1881.	1882.
United States ...	834,548 tons.	897,732 tons.

In regard to the above figures, I confess to feeling sceptical save with reference to those of the United States and England. Nevertheless, granting that they do not give the full amounts by one-half, even then the United States stands second in the list of salt-producing countries.

What, then, constitutes a really considerable industry?

GEORGE P. MERRILL.

U. S. National Museum, Washington, D.C.,
December 3, 1887.

Force, and Newton's Third Law.

THE point mentioned by "Nemo" in your issue of March 29. (p. 511) is undoubtedly one that troubles most students at some stage or other, but there is no room for discussion about it; the matter lies in a nutshell: *a body does not exert force upon itself*. Think, for instance, of a horse and cart. The horse pulls the cart, and the cart pulls back the horse equally; how, then, can the cart move? The only puzzle lies in the false implication that the cart's pull-back is exerted upon the cart. Directly it is perceived that there is only one force acting on the cart, viz. the pull of the horse, no difficulty is felt as to why it moves. The "action" of A is not exerted upon A, but upon B. The "reaction" of B is not exerted upon B, but upon A. The time-rate of change of momentum of each and every body is equal to the total force acting upon it. OLIVER J. LODGE.

Grasmere, March 31.

The New Photographic Objective.

THE letter of Sir Howard Grubb in your issue of March 8 (p. 439) appears to make some further explanation desirable on my part. The invention of the new form of photographic objective seems to have been made about the same time in America and in England. An experimental lens of this kind was constructed by the Messrs. Clark, after consultation with me, in May 1887. The 13-inch lens which they subsequently made upon the same plan was completed on July 8 of that year. My absence during the summer in Colorado, with the intention of selecting a place for the new instrument upon some mountain of considerable height, caused me to overlook the account of the English invention in the *Observatory*. Since my return, the telescope has been mounted in Cambridge, on the grounds of